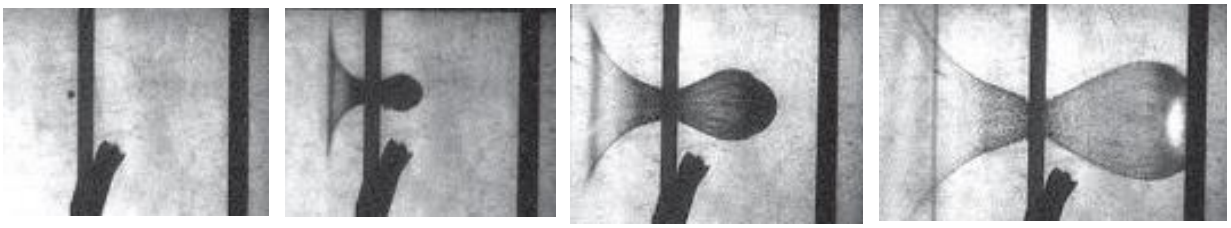
National Aeronautics and Space Administration

Hypervelocity Impact Technology Team

NASAfacts

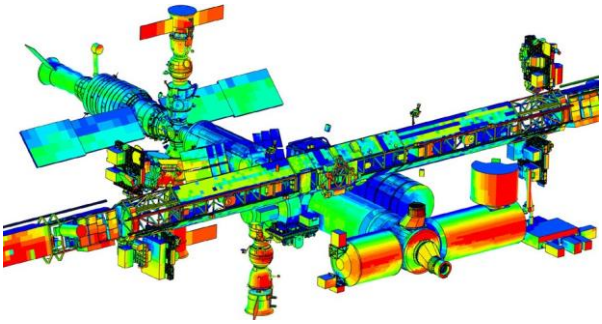
The NASA Hypervelocity Impact Technology (HVIT) team is the agency leader in engineering and operational solutions to protect spacecraft from micrometeoroid and orbital debris (MMOD). HVIT predicts MMOD risks to spacecraft, collaborates with spacecraft teams to optimize shielding and mission designs to minimize risk, assists spacecraft programs in defining MMOD risk requirements and develops new shielding technologies and concepts. Hypervelocity impact testing, computer simulations and damage equation development form the foundation of the HVIT analytical suite, which along with decades of practical mission experience, contribute to crew safety and mission success. HVIT services and products are not limited to NASA, but also serve the private spacecraft sector and other space agencies.



Simulated 7 km/second orbital debris impact into spacecraft protective shielding using a two-stage light gas gun.

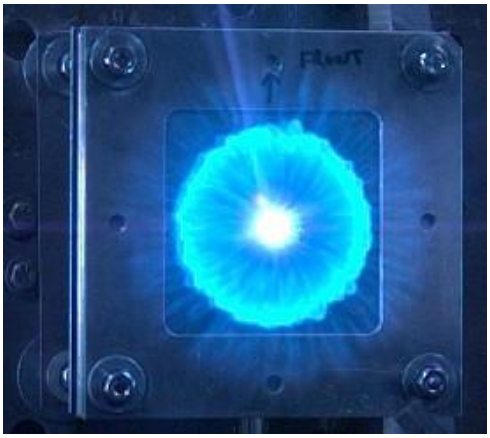
Risk Assessments

In the past 30 years, HVIT has provided MMOD risk assessments for all crewed and numerous non-crewed spacecraft with missions in low-Earth orbit and deep space. The assessments identify areas of a spacecraft that are predicted to be more vulnerable to MMOD impacts and require more protection than other areas, as well as identify vehicle regions that drive overall mission MMOD risk. The HVIT team has the capability to rapidly produce finite element models of spacecraft that are compatible with their risk-analysis tools, the primary tool being the Bumper assessment code.



International Space Station MMOD impact risks.

red = high impact risk
green = medium impact risk
blue = low impact risk



MMOD shield hypervelocity test showing flash.

Hypervelocity Impact Testing

HVIT designs and fabricates precision spacecraft shielding mock-ups to undergo high-speed impact testing. Impact testing is conducted in partnership with the NASA White Sands Test Facility Remote Hypervelocity Test Laboratory (WSTF/RHTL), which uses two-stage light gas guns capable of launching 0.05 mm- to 25.4 mm-diameter projectiles at speeds of 1.5 km/second to 7.5 km/second. Test diagnostics include projectile velocity measurement, projectile integrity verification, ultra-high speed photography, shadowgraph photography and flash X-ray photography.

Analytical Impact Simulations

HVIT uses specialized computer programs called “hydrocodes” to simulate how spacecraft shielding may respond to a hypervelocity impact before actually testing the spacecraft hardware. In this way, HVIT can tailor a test plan to save time and reduce costs. Additionally, hydrocodes can be used to estimate spacecraft shielding performance in conditions that are beyond current impact technology capabilities, such as at extremely high velocities above 10 km/second.

Damage to 2-inch-thick aluminum caused by a 10 g Lexan® slug at 7 km/second.

Note: Quarter for scale in corner of each target.

Simuluated debris impact by a 1.3 cm diameter sphere at 7 km/second.

Shielding Technology

The HVIT Team develops MMOD shielding technologies and holds several shielding design patents. The team investigates multi-functional shielding that goes beyond stopping particle penetration, such as designs to help ground-based teams identify impact location following particle collision, and designs that reduce radiation exposure to protect astronauts and extend the life of a spacecraft.

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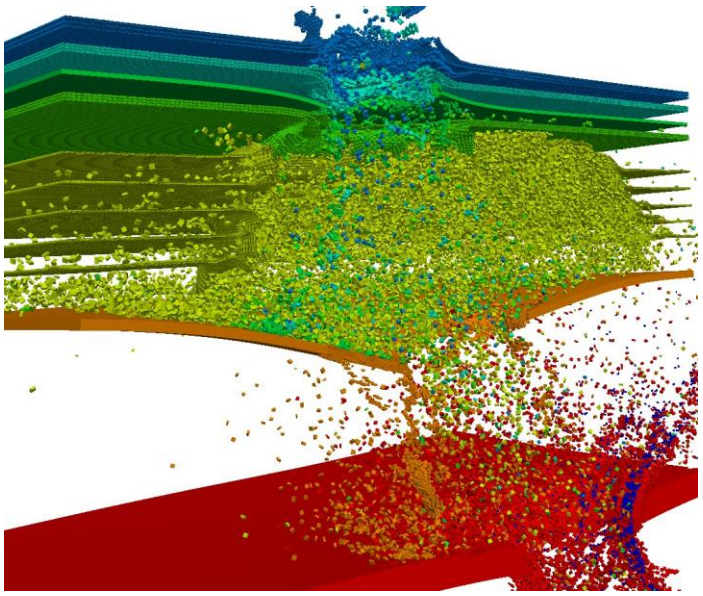

Hydrocode impact simulation of spacecraft thermal blanket (light blue to green), external bumper (orange) and pressure wall (red). Disrupted projectile remnants are shown as dark blue at the bottom of the graphic.

Ballistic Limit Equations

MMOD risk assessments require that each shield type on a spacecraft be assigned a ballistic limit equation (BLE) to describe the particle size that would cause the shield to fail as a function of impact velocity, angle, density and shape. Small spacecraft may have only a few BLEs, whereas larger spacecraft may have hundreds. Thousands of tests have been methodically analyzed to create an extensive catalog of BLEs for a wide variety of surface materials and shielding configurations. The HVIT team continues to expand the BLE catalog as new spacecraft and shielding technologies emerge.

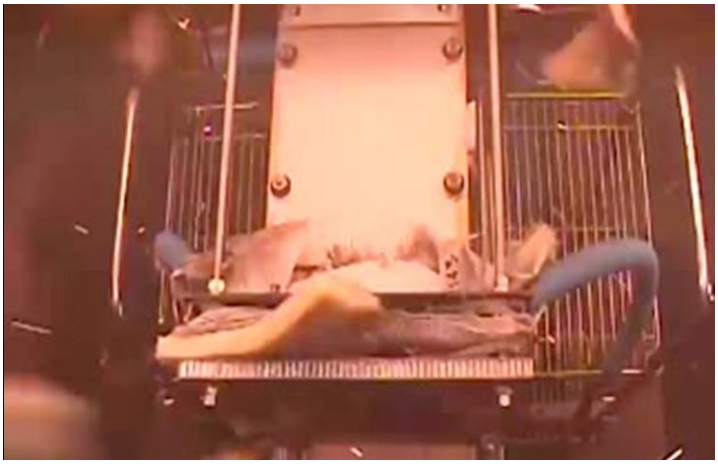

Photo of the hypervelocity impact test on spacecraft lithium-ion batteries, showing thermal reaction to impact.